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**PROCEEDINGS OF THE  
PHILADELPHIA FOUNDRYMEN'S ASSOCIATION.**

The seventy-fifth meeting of the Foundrymen's Association was held at the Manufacturers' Club in Philadelphia, on Wednesday, February 2, the president, P. D. Wanner, presiding.

After the routine business had been disposed of the following resolution was passed by a vote which was unanimous:

"Resolved, That the Foundrymen's Association of Philadelphia declares itself in favor of maintaining the gold standard, and respectfully urges the enactment by the Senate and House of Representatives of the United States of necessary laws to strengthen the public credit on the lines laid out and recommended in the report of the Monetary Commission of the Indianapolis Convention.

"Resolved, That the Foundrymen's Association of Philadelphia heartily concurs in the sentiments expressed by the President of the United States in his speech before the meeting of the National Association of American Manufacturers in New York City, and pledges to him the support of the Foundrymen's Association of Philadelphia in his efforts to maintain the credit of the United States Government."

Francis Schumann, president of the American Foundrymen's Association, announced the formation of a defense association

among foundrymen at a meeting held in New York, and gave some details of the proceedings. Mr. Schumann stated that he thought a discussion of the subject by the Philadelphia organization was highly important, and moved that such discussion form a part of the proceedings of the next meeting of the association. The motion was carried without dissent.

Linson H. De Voe, of the Staten Island Clay Company, Woodbridge, N. J., then read a paper on

#### CUPOLA LININGS.

Telling a foundryman how to line a cupola is not unlike carrying coal to New Castle; unless we assume that a day is poorly spent when nothing is gained. During the first years of my connection with the fire brick industry, that which attracted my particular notice was the cupola. Between the foundryman and the fire brick maker, disputes, at times, arise. Is the fire brick manufacturer always in the wrong? If the bricks are first quality, should not as much care be used in laying up the bricks as in the manufacturing? This evening, I propose to explain how the cupola should be lined to give best results. Many cupolas have been and are lined as I will explain, and good results always follow.

To line a cupola the first step is to procure fire bricks. What quality of fire bricks? The best for that class of work. Then comes the question of cost. How do you intend to line—single or double lining, blocks or 9-inch bricks? Decide as you will, the order usually goes to the lowest bidder. But is it always best policy to do so? Are you practicing real economy? Is the cost of the lining of such magnitude that it requires much study? Later on, I propose to show you that the cupola lining is one of the smallest items of expense in the foundry, if not the smallest.

There are several good methods of lining a cupola, any of which are satisfactory and economical if the bricks are laid skilfully. We will treat of them separately.

Single lining, using blocks: The term "block," as here applied, refers to a fire brick of twice or more times the bulk of a standard 9-inch brick. There is no good reason why blocks should not outlast 9-inch bricks, unless improperly laid. You are well aware that the shell of the cupola expands when heated; but perhaps you never have noticed that the immense pressure exerted against the lining while filled with molten iron causes the lining to expand against the shell. When the cupola cools, contraction of the shell occurs, but, the bricks, being coated with iron and cinder, do not respond to this fearful pressure, or squeezing; consequently they are crushed and cracked. To all outward appearances, the bricks are as good as ever, and not until the man cleans out in the morning and the bricks crumble, does any change appear. Then the bricks are condemned, but nothing is said about the laying of them. This occurs during the first two or three melts in a new lining.

- Two occasions only have I known in which the foundryman realized the cause of the rapid disintegration. To avoid this, when laying the bricks, leave a space between the shell and the brick, of one-half or three-quarters of an inch and fill this space with dry, finely ground cinder and fire clay mixed. This acts as a cushion and takes up the expansion and contraction.

Single lining, using 9-inch bricks: The various 9-inch segment bricks, such as arch, bull-head, wedge and key, are made in so many sizes that almost any circle up to 84 inches diameter may be laid with them. Naturally more care must be observed in laying these, as they present many joints for the molten metal to attack. Frequently, two or more sizes are combined to turn the circle perfectly. The melter and his helper are the best hands to employ to do the work, as masons usually make the bonds between the bricks too large, where only the very thinnest mortar should be rubbed on for bonding. In fact, some foundries simply dip the bricks into mortar made almost as fluid as water; and that is the best method, but more time is required drying before running off a melt. Whether the bricks are laid to make a  $4\frac{1}{2}$ -inch or 9-inch wall, the same rule will apply as regards spacing

between wall and shell. When the bricks are laid against the shell, with the  $4\frac{1}{2}$ -inch wall, the crushing and disintegration is not noticed to any extent, but the wall soon loses its regularity and becomes prey to the cinder and slag. In the 9-inch wall, the crushing and disintegration are more noticeable than in the block lining. The spacing is an essential, regardless of the size of the bricks.

Double lining—9-inch bricks and blocks: This method is in general use and should be the most economical of all linings, unless too much economy is observed at the outset. Many foundrymen, to save a few dollars, have the outer lining, the one against the shell, a  $2\frac{1}{2}$ -inch wall. As there are no 9-inch segment bricks for laying in that manner, the "square" brick is used; but you very readily see that the space formed by the angles at the back of the brick as well as between the shell and the long-side brick—the length of the latter being the chord of the arc formed by the shell—must be filled in, so that some sort of bond is effected. The fire clay mortar soon dries and crumbles and this wall loses its stability. To avoid that trouble and annoyance, lay a  $4\frac{1}{2}$ -inch wall of 9-inch arch bricks; see that the job is well done and every joint tight, and you have a protecting wall which will last many years. It is advisable to lay the inner lining of blocks close to the outer, without any space between. Iron sometimes works through, and should there be any space for the iron to run down, the two walls become cemented, necessitating breaking and repairing what would otherwise have been a permanent lining.

The economy in double lining consists of the amount of work which the inner wall will perform. As there is no danger of the shell being burnt, it being protected by the permanent lining, the blocks may be used until nothing remains but a mere skin. In fact, the cupola always has a lining, and the annoyance of having the foreman advise you that "the lining has worn through to the shell and we can't run off another heat until the cupola is relined," is avoided.

Double lining—two  $4\frac{1}{2}$ -inch walls, 9-inch bricks: There are many objections to this method, the principal one being lack of stability. Having but  $4\frac{1}{2}$  inches bearing surface, and being 9 inches high each row, the inclination is to top-heaviness, which soon becomes apparent by the wall bulging, requiring frequent repair. Naturally the cupola expense account is rather heavy, and the foundryman goes from one manufacturer to another, in his endeavors to obtain "good" bricks. In the majority of instances, the fire bricks are first class; the actual trouble being in the foundry. Intelligent discrimination in the selection of the proper lining for the work required, as well as quality, would save money for the foundryman; and the fire brick maker would not receive so many complaints.

Keep on hand an extra lining; it is good assurance. Accidents occur when least expected. No one expects the blower or wind-pipe to break down; but if either should occur, the lining would be a dead loss when the iron was broken out of the cupola.

When laying bricks during cold weather, see to it that they are absolutely dry. The moisture they absorb from the fire clay is sufficient to make them "set" after laying. A good way to drive frost or moisture out of bricks is to set them around the boilers or over the core ovens.

Dip the bricks into very thin mortar and rub them down to as tight a joint as possible. Do not lay in mortar as though they were red bricks. Every man who lays bricks in a cupola will say that he does not use thick mortar; but there are many opinions as to just what defines thick and thin. Never use a metal hammer to hit a brick; a mallet will give all the force needed without injury to the brick; but a hammer will crush or crack fire bricks at every blow. The fire mortar, or fire clay, must be of excellent quality, or the molten iron may flux it. Select, when possible, enough hard-burned bricks to lay up for two or three feet opposite and below the charging door. Some melters are careless and throw pig and scrap with such violence that the lining opposite the door is destroyed more rapidly than that above the tuyeres. Many fire bricks are condemned through

the recklessness of the man who "chips-out" in the morning. He endeavors to rush matters which should be done carefully.

In many instances the man is not to be blamed; the heap of cinders below the bed plate has not cooled to any extent and has been adding its heat to that of the cupola's interior. Consequently the job is too warm to linger over. But that excuse will not apply to all cases, and great care should be exercised to the end that the bricks are not broken or chipped unnecessarily. I find that very little supervision is given to that part of the work, and many times good bricks have been condemned owing to the helper's indifference. If the wind is shut off two or three minutes before dropping the bottom, and some iron left to run out with the cinder, the tendency of the iron is to drag out a goodly portion of the cinder which would otherwise adhere to the bricks.

Running out the last pound of iron and then shutting off the wind is a detriment to the bricks.

As to the qualities necessary to make good bricks: The clays must be highly refractory, blended in such manner that the finished article for the work intended (in this case cupola linings) shall be fairly close, hard enough to stand erosion and jarring, yet porous enough to expel quickly the heat absorbed during the melt.

To buy cupola bricks on the strength of chemical analysis is an unwise proceeding. Analysis of fire bricks for some work is like statistics. When trustworthy, they sometimes make one feel very uncomfortable.

In conclusion, I beg to submit estimate of cost of cupola lining, for one year, per pound of iron melted. This estimate is not a theory, but taken from figures furnished by foundrymen to me at various times.

I find that there are more cupolas 60 inches diameter lined down to 48 inches than any other size, and have adopted that size for my illustration. Usually that size is lined for 15 feet with cupola blocks, which brings it to the top of the charging door. Above that height, the lining will last many years. The prices

given are based on small quantities, less than carloads, and are purposely quoted at an advance over the actual selling price. Labor, however, is the average wages paid in 20 shops:

Sixty-inch shell, lined to 48 inches—17 blocks to a course of 4 feet high.

Cupola lining, 15 feet (cost put in foundry).....	\$100.00
Fire mortar, to lay above.....	4.50
Labor, 2 men, 1 day, at \$2 per day each.....	4.00
Relining at melting zone at end of 6 months, say 4 feet..	26.80
Labor, 2 men, $\frac{1}{2}$ day each.....	2.00
Labor, "picking" and cleaning interior of cupola daily for 280 working days*—1 man, 2 hours daily, at 18c per hour .....	100.80
Clay required for making "daub," about 5c daily.....	14.00
Total cost lining and repairs end of year.....	\$252.10
9 feet of this lining is still good for at least another year, hence is worth 50% of original cost.....	32.85
Net cost lining .....	\$219.25

#### DISCUSSION.

Mr. Schumann: Do you recommend instead of two thicknesses of lining one thickness equal to two, or one block equal to the two separately?

Mr. De Voe: We like to make blocks that way, but from my observation I would not recommend it. We think it far better to have one permanent lining in. When your man cleans out in the morning and gets down to that inner lining he knows he has  $4\frac{1}{2}$  inches left for him, and that might be used for a few days if necessary. You may be sure your fire will not go through

\*Note—This allows for 61 holidays and Sundays and two weeks for stock taking.

The product of a cupola this size is about 10 tons daily average, or 2,800 tons annually=5,600,000 lbs., making the cost .0039 of 1 cent per pound of iron melted.

that. A great many foundrymen are using No. 2 bricks for outside lining, and the difference in cost between No. 1 and No. 2 bricks is very slight.

Thomas Glover: Does it make any difference whether bricks are hard or soft for cupola linings?

Mr. De Voe: I should recommend a hard brick. A brick well burned on the outside yet retaining its color will give better results than a light colored brick. Clays having such a refractory nature as to stand the intense heat of the hottest part of a kiln, and which in brick form take on a nice flesh color, showing a good quality when the brick is broken open, produce a brick which will give you the best work.

Mr. Evans: When you speak of a hard burned brick, you mean a brick that has been closer to the fire?

Mr. De Voe: It has been where the hottest part of the fire catches it. When we set a kiln the quality of the brick is first considered, and we put No. 2 the furthest distance from the fire. They do not require so much fire as No. 1. On a down draft kiln the hottest fire is at the top, and there we put the No. 1. At the bottom of the fire we put the No. 2.

Mr. Evans: Then there must be some No. 1 bricks which have not had the greatest amount of fire.

Mr. De Voe: We try to make the distribution as equal as possible. From top to bottom there is an equal color, and we take that care in distribution.

Mr. Evans: We will suppose that in a kiln of bricks some of the bricks are not as hard burned as those closer to the fire, and you take those bricks and put them in a cupola not exposed to the hot fire, do not you get the same thing then?

Mr. De Voe: No. The second burning of a soft burned brick will tend more to petrify than to burn. The very light colored bricks we throw away; we do not sell them.

Mr. Schumann: The criticism is often made that the double row of tuyeres in some foundries cuts off the brick quicker. What is your experience in regard to that?

Mr. De Voe: I certainly find that a double row of tuyeres cuts out the brick faster than a single row.

Mr. Schumann: What is that due to?

Mr. De Voe: I really don't know. It may be that the bricks are struck with a current of air anglewise, because they certainly appear to be so struck.

## PROCEEDINGS OF THE WESTERN FOUNDRYMEN'S ASSOCIATION.

The regular monthly meeting of the Western Foundrymen's Association was held at the Great Northern Hotel, Chicago, Wednesday evening, February 16, 1898, President C. A. Sercomb, in the chair.

The paper of the evening, "Mechanical Changes in the Mixture of Cast Iron," by Eugene W. Smith, was then read by its author. It is as follows:

### CHANGES IN FOUNDRY MIXTURES.

In the discussion before the Western Foundrymen's Association in February, 1897, on "What is the proper amount of air, and pressure of same to melt iron in the cupola, and what are the effects of too little or too much air?" the third division of the question was quite thoroughly discussed. The general opinion was that the changes in iron are probably due to mechanical changes. Mr. Dalton attributed hard iron in the first part of the heat to the condition of the cupola. Mr. Pettigrew claimed that the first iron is softer, providing the cupola is dry. If the conditions are constant, why should not the results be the same? Mr. Coffeen supported the theory of open cupola and excessive blast pressure, by his statement that he found it necessary to use softeners in the first part of the heat. Mr. Ferguson advocated using all the blast pressure obtainable, but stated that iron is harder at the beginning of the heat. If the mixture is the same, should not the result be attributed to a mechanical condition existing in connection with the cupola?

The deductions obtained at that time by Mr. Carter served to show that the figures given were pretty close as to amount of air required, viz.: Mr. Sorge, 2,500 lbs. of air per ton melted; Mr. Thompson, 3,000 lbs. of air per ton melted; Mr. Hanna, 3,000 lbs. of air per ton melted. Thus we see that the members who were prepared to discuss the amount of air required came very near agreeing.

The members who discussed the effect of blast, practically agreed that there was a difference in the first iron melted, but did not go far enough and find the cause, which the writer thinks might be attributed to some mechanical change, as expressed in this paper.

Mechanical changes which occur in cupola practice often serve to confuse the foundryman who is otherwise very careful as to the charges which he gives to his melter.

Every now and then someone gives a theory to explain why the first iron is harder than the last, and another will give a reason why it is softer. Each demonstrates the matter to his own satisfaction in scientific terms, citing the destruction of silicon, combining of carbon, effect of sulphur, etc., but all this only serves to mystify the ordinary foundryman who has not had the advantage of a college education.

All conditions being equal, results should be the same, no matter at what period of the heat the charge is melted, the differences being due simply to some mechanical change due to handling. Some of these changes the writer will try to describe in the present paper, showing the absolute care which must be taken in handling to obtain uniform results.

1. A very common source of error occurs in the charging room in weighing up the charges. Sometimes a certain brand of iron is not broken as small as others and the charger is not careful as to balancing his scales, causing variations at different times during the heat.

2. The placing of iron in the cupola in such a manner as to cause uneven melting, allowing one brand to melt and mix ahead of others, frequently causes trouble.

3. Improper drying of the cupola is probably one of the most frequent causes of hard iron in the beginning of the heat, particularly so if receiving ladle, hand ladles, etc., are not thoroughly dry, or even cold, causing changes in the condition of iron by chilling.

4. Probably the most important cause of change in the first iron melted is the excessive use of blast. The cupola at that time

is probably in its very best condition. The fuel resembles an open net-work, somewhat like a sponge, unobstructed by slag, which does not begin to form until considerable iron has been melted. The tuyeres also remain unsealed, and if conditions are otherwise all right, the iron will be exposed to the oxidizing effect of the blast while trickling through the fuel, serving to harden it.

This is generally attributed to a chemical change caused by sulphur in the bed charge of fuel. But there is no good reason why the sulphur should predominate any more in the first charge than later in the heat; or, as is sometimes the case, on one day more than the next, when the same fuel is used. It is also attributed to the destruction of silicon, which is probably the true effect, but not the cause. It is simply a condition which should not exist, as the heat required is no greater at that time than later on. True, it is hard to draw the line by calling it a mechanical change when the carbon has been combined no matter by what cause. Still it may be avoided mechanically, where control of the blast may be had, by reducing the pressure to the lowest point possible without delaying the melting process.

This trouble is met with in all foundries more or less, except where large amounts of iron are carried in the cupola. In such cases the effect of blast would not likely be apparent.

5. Another source of error, caused mechanically, occurs where the iron is drawn off faster than it is melting, not allowing it to mix properly, thus obtaining hard iron at one time and soft at another.

6. A change in condition occurs where the slag-hole is used and the cupola is held too full, allowing the slag to clear off the iron, thus exposing it to the oxidizing effect of the blast.

7. Still another change is caused where the lining of the cupola has been made too hot in drying out, which sets fire to the fuel charges above the melting zone at one side or the other, causing the stock to come down unevenly.

8. Very often the tuyeres are formed unevenly, with larger openings on one side than the other, causing the stock to melt faster on one side, thus giving an uneven result.

Another instance occurs where economy in the use of fuel is practiced. The bed may be all right and heat started successfully, but by the excessive use of blast the bed of fuel is gradually decreased, until at last, when charging is all done and the doors closed, the iron melts too close to the tuyeres, which is almost invariably a cause of hard iron. Soft fuel under the same conditions would likely have the same result. In the above case an excess of thin fluid slag, about the consistency of soap-suds will be noticed, very foamy and light; and if the blast is excessive, the slag will be held up by its pressure around the sides of the cupola, also giving off a peculiar puffing sound very easily noticed. It cannot be drawn off until the blast pressure has been reduced, which must be done gradually and carefully, or the slag will flow into the tuyeres first. The hard iron in this case could be attributed to the destruction of the metalloids, nevertheless it is a mechanical change in the mixture which would not have happened if the melting had been done properly.

The above items only apply where the iron melted does not exceed eight tons per hour and the stack does not exceed 48 inches diameter. Neither do they apply to any particular grade of mixture. The effects would probably be the same whether hard or soft irons were melted.

#### DISCUSSION.

Mr. Smith: One point I wish to raise is, that in our studies of the theoretical we must not lose track of the practical side. The deductions arrived at in this paper are the result of close observation of the workings of the cupola under various conditions. It must not be understood that I infer that the effects are not chemical effects. I simply show that they are caused mechanically. Nor are all of the instances mentioned in which changes might occur. Probably no two foundrymen present are melting iron under the same conditions, either in class of work, size of cupola, or arrangement of tuyeres. Therefore it will be very easy for some of the members to differ with me as to the various causes presented. In some of the points raised my interpretation of the

causes may be wrong. In that case, I shall profit by the experience of others. Now in regard to No. 1, that, I believe, is plain to the members. Referring to No. 2, the proper manner of placing iron in the cupola is similar to the spokes of a wheel as pig iron melts from the ends first and the center of cupola should be the hottest. Where scrap is used, in some places larger pieces are used in excess, and in some places regardless of position in cupola, causing uneven mixtures. A great deal depends in this case upon the man who does the charging and his reliability and intelligence, and as the manner of charging and weighing up is not the same in all foundries, no set rule can be given to cover all cases. The foreman will have to guard these points in his instruction to the melter. Coming to No. 4, governing the blast in the beginning of the heat is very apt to be misunderstood. I do not wish to convey the impression that a light blast is required at all times. But I do contend that the blast should be used as light as possible (without delaying the melting process) at the beginning of the heat, and gradually increased until speed of melting suits the requirements, otherwise the results will not be the same. I understand that a stronger blast would be required with small coke than with large; and the same is true with coal. Where soft coal is used the blast should necessarily be lighter. No. 5 will probably only apply in cases where slow melting is required as in hand ladle practice. No. 8 is not an argument for any particular class of tuyeres, as the results would be the same under like conditions. Since writing No. 9 I recalled a case (and probably some of the foundrymen present have seen the same thing) which I saw a few years ago, of a cupola in which the charging doors had not been closed and the slag had not only been held up by the pressure of the blast in the manner stated, but it had also been blown up to the roof of the charging room. I was not in a position at that time to consider the cause.

Mr. Ott: I would like to inquire about the remark concerning overheating the lining of the cupola.

Mr. Smith: That does occur where the cupola is heated up too high and the bricks become heated in the lining of the cupola.

It is where the cupola has been heated red hot and the iron charge is small and the fuel charge is close together.

Mr. Ott: When you speak of the cupola, do you mean the outside or the inside of the lining?

Mr. Smith: I mean the inside.

Mr. Ott: In regard to the hard iron. I have got hold of coke that was full of sulphur. On the first heat the iron would come out hard, but as soon as the cupola was ready for the second heat the iron would come out softer. It must be the sulphur that caused the first iron to be hard. If sulphurous coke is used, we will naturally get the iron harder in the first part of the heat. I am always on the lookout for sulphur in the coke. I understand that some claim that the first iron is softer. I have never found it so, and I have melted iron since 1860. I have never found the first iron the softer unless the fuel was absolutely clear of sulphur. Years ago we used coal altogether. It is easier to melt with coke than coal. I did not notice the difference so much then; perhaps I was not so well posted. I remember having trouble with iron during the first part of the heat. I laid it to the coal and the wet lining of the cupola. Frequently the cupola is daubed up with wet mud.

Mr. Smith: I take the stand that the sulphur in the first part of the heat is a popular fallacy. Mr. Ott states that during the war he used coal. It appears to bear me out in my theory. With coal we know we require a harder blast. It packs closer.

Mr. Ott: I never allow my melters to put a full blast on in the beginning of a heat. If too much blast is put on the body will be lower and the iron too near the tuyeres and you will have hard iron.

Mr. Smith: In regard to the sizes of the iron, Mr. Ott is right. I believe in getting the iron broken up as uniformly as possible. By charging with too large pieces of iron, the iron is very apt to hang between the charges.

Mr. Thompson: It has not been my experience to notice that we have no harder iron in the beginning of the heat than toward

the end. In fact, we make it a practice to pour our pulleys and machine work in the first taps. We do that for the reason that in charging up we know just when the charges will melt and know just what kind of iron to expect. We probably put on softer iron in the beginning of the heat. But where, say, a ton of iron is allowed to accumulate in the cupola before tapping up I think the tendency toward hardening the iron which might occur through oxides of iron or a wet bed is overcome in that quantity of iron. I believe that the first hundred pounds of iron melted will have a tendency to harden, but that is so little if we allow a ton to accumulate that the effect will not be felt. I do not know of any case where we ever got hard iron out of the first tap any more than at any other time during the heat. In regard to the amount of air which should be allowed to go into the cupola. Mr. Ott states that when the blast is commenced he does not have so much pressure. It requires a certain amount of air per ton to the iron melted and I do not think that the slowing of the blast at the beginning of the heat would be in any wise beneficial, and that is sometimes very difficult to do. That can only be done when you have a special engine attached to the blower. I do not think that it would be a very practical method in the generality of foundries to use less pressure of blast at the beginning of the heat.

Mr. Smith: In regard to carrying a thousand pounds of iron in the cupola, I would like to call your attention to reverberatory furnace practice. There it is given an excess of top blast if you want to run the iron up, and it is practically the same thing that causes hardening in the cupola, provided you have raised the iron up and cleared the slag off the surface of the iron the same as you would in the reverberatory practice.

Mr. Ferguson: Referring to the classified statement Mr. Smith makes in regard to the handling of the cupola, I take exception to his assertion that there is as much difficulty to obtaining sulphur in the middle of the heat as there is in the beginning. We will say that in a 40-inch cupola it will take 850 or 900 lbs. of fuel to bring the iron up to the proper height. In subsequent

charges it is only a matter of 150 to 175 lbs. The first iron charged in the furnace must necessarily pass through all this body of fuel and there is necessarily more sulphur taken up from 850 or 900 lbs. of fuel than from 150 lbs. That would be the only way of accounting for the iron being harder in the first heat. It has always been a puzzle to me how to get rid of the hard iron. I do not see that we have any data in regard to the degree of hardness. I would like to know the difference in the irons tapped from the first and subsequent heats. I do not think that we can gain much knowledge from the statement that the iron is harder in the first heat. Mr. Smith, in his paper, charges me with saying that I applied all the blast I could get. In connection with that, he did not tell the whole story. I had found, it seemed to me, that the mechanical men had arranged matters so that it was impossible to get too much blast. I had no way of reducing the blast pressure without reducing the speed of the melting. I had never, as I said, had so much blast that I considered it detrimental to the iron.

Mr. Blackburn: Our experience has not been that we got much harder iron on the first heat. I would agree with the last speaker that we would get from the extra amount of coke more sulphur, but we have not found it so in our experience.

Mr. Stantial: Invariably it has been my experience that the first iron out of the cupola is harder than later on. That poured from the first tap is invariably harder and the fracture of lighter color. When it comes to the chemical composition, I have found that the carbon in the first iron is higher than in the later, silicon about the same, usually found higher, sulphur sometimes higher, but oftentimes the same. The reason, I believe, to be the condition of the cupola. The lining is cool, everything is cool as compared with the condition later on during the heat. On the question of blast, I agree with Mr. Smith. I think it should be lighter by several ounces at the start of the heat, and later on, when everything is well and the iron melting, it should be raised. It is my practice for the first 15 or 20 minutes the blast is on to run

the blower at a lower speed than later on. In this way I believe I have obtained better results.

Mr. Stockham: I am convinced that all results, detrimental and otherwise, can be governed almost absolutely by the proper proportion of metalloids. As far as my experience goes, it leads me to believe that if we eliminate from consideration the first quarter or half ton of iron that would come out of the cupola, any variation that would occur during the remainder of the heat would be so slight that it would be immaterial for practical purposes.

Mr. Stantial: In regard to the size of the heats I have noticed the same phenomena with heats of 85 tons and heats of, say, 5 tons.

Mr. Stockham: I would like to ask Mr. Stantial a question. Were your test bars taken from the first tap in which would naturally appear the first quarter or half ton of iron?

Mr. Stantial: They were taken from the first ton out of the first charge that comes out of the cupola.

#### DISCUSSION OF MAJ. McDOWELL'S PAPER.

Maj. McDowell: Before opening the discussion this evening, I want to express to this association my sincere thanks for the honor you have conferred upon me this evening. I will frankly say to you that, although I have occupied a great many places, both social and political, there is nothing that has come so near to me as my election to-night as an honorary member of this association. We are here together for the purpose of building up what I think is one of the grandest professions. I find it impossible to express to you my gratitude for making me an honorary member of such a society.

In regard to the effect of metalloids upon iron I would like to call your attention to the table on page 183. This tabulated statement is not perfect nor accurate in all its details, nor is it up to date in price or analysis, but it is harmonious and sufficiently accurate for me to use in illustrating the question now before us. To facilitate following the data, the

horizontal lines are numbered, and the vertical columns are lettered.

No. 1, column A, is Swedish, wrought charcoal iron having a tensile strength of 48,000 lbs. per square inch, and a value, Column C, of \$52 per ton. The chemical analysis shows total carbon, .15; silicon, .05; phosphorus, .003, and entirely free from sulphur and manganese. In column I the total amount of iron is 99.797, and column K amount of metalloid is .203, showing a very remarkably pure metal. This iron is made direct from ore, and from start to finish the fuel is charcoal. It is made from a

A	B	C	D	E	F	G	H	I	K
Name and kind of metal.	Tens. strength 1 inch area,	Value per ton.	Total carbon.	Silicon.	Phosphorus.	Sulphur.	Manganese.	Total amount of iron.	Total amount of Metalloids.
1 Swedish charcoal wrought iron .....	48,000	\$52.00	.15	.05	.003	.00	.00	99.797	.203
2 Burden's best wrought iron .....	56,000	48.00	.04	.018	.167	.00	.00	99.687	.233
3 Common bar iron.....	48,000	25.00	.07	.14	.10	.02	.00	99.67	.330
4 Bessemer rail steel.....	64,000	22.00	.35	.034	.10	.05	.85	98.616	1.384
5 Low carbon steel.....	62,000	30.00	.15	.021	.05	.03	.75	98.996	1.004
6 Tool or crucible steel.....	150,000	200.00	1.50	.10	.006	.00	.50	97.895	2.105
7 No. 1 foundry pig iron.....	18,000	12.00	3.65	2.80	.75	.61	.30	92.49	7.510
8 No. 2 foundry pig iron.....	19,000	11.50	3.29	2.25	.70	.02	.40	93.04	6.66
9 No. 3 foundry pig iron.....	20,000	11.00	3.25	1.95	.30	.05	.55	94.90	6.10
10 Gray forge iron.....	18,000	10.50	3.80	1.00	.65	.07	.52	94.96	6.04
11 Mottled forge iron.....	17,000	10.00	3.75	.90	.50	.09	.74	94.02	5.98
12 White forge iron.....	16,000	9.00	3.65	.40	.25	.25	.80	94.60	5.35
13 Bessemer pig iron.....	17,000	11.50	3.50	1.50	.05	.03	.35	94.57	5.43
14 Bessemer pig iron for O. H. ....	20,000	11.00	3.25	1.00	.15	.03	.39	95.27	4.73
15 Malleable pig iron.....	20,000	12.00	4.00	.75	.04	.01	.40	94.80	5.20

peculiar ore, well adapted to this special kind of treatment, requiring very nearly four tons of ore to make one ton of finished bars. The ore is calcined, then washed and sometimes reduced to plate iron from a furnace, but as often the calcined ore is changed direct on a bed of charcoal on an old-fashioned sinking fire or Catalan forge, each charge consisting of a bed of charcoal, then plate iron or iron ore, until sufficient charges are made to make a heat.

No. 2 is Burden's Best, which is in this country a typical iron for general usefulness, and is reliable in regard to its tensile strength. It works with great ease and smoothness when hot,

under the hammer or in the rolls, and when cold can be riveted solid. In drawing a comparison between it and the line above, Swedish iron, there is a difference in tensile strength of 11,000 lbs. in favor of Burden's Best, but as in column C there is a difference of \$4 in favor of Swedish, naturally the inquiry would be, What is it that makes these great differences in physical strength and commercial value? Take column F, line 2, phosphorus 1.67. It is this that bars its use in making crucible tool steel, and it is the same metalloid that gives to it its great tensile strength, and great malleability, and this is on account of its not being embarrassed by the high carbon shown in column D, line 1. The difference in the total amount of metalloids in these two metals as shown in column K is .030, and this is accounted for in the two items of carbon and phosphorus, where one is high and the other is low, and this difference gives to each metal its peculiarities and respective value.

No. 3 is common bar iron and like Burden's Best is puddled. By comparing the one with the other, we find the former carrying, column K, .097 more metalloid than the former, and while this is quite enough to account for the large difference there is in the commercial value and physical strength, it is not altogether due to it, for each employs a puddler at a scale of prices arbitrarily fixed by an association. Burden's Best pays a premium for quality, and quality can only be produced with an intelligent effort during a high heat. Although quality as well as quantity is a consideration, and when a premium is paid for the former, it is an inspiration to produce Burden's Best; where mere tonnage is the consideration, the puddlers' inspiration in working is to leave all the cinder he can incorporate in the puddle ball, and make it stick together, and this is common wrought iron.

No. 4 is Bessemer rail steel. The name is aptly applied; for with a few exceptions Bessemer steel is limited to rails, and is a metal eminently suited for that purpose. It is more a semi-steel than a steel, being too low in carbon to give any of the peculiarities and valuable qualities of steel, and too high to rank with iron, and although it is high in tensile strength, it is cold-short, and therefore condemned for structure and boiler-plate work.

It seems wonderful that the commercial value of the tensile strength may be influenced by so small a fraction of a metalloid. That is in wrought iron. The same rule holds good as we go along all through the question of the value of metalloids as combined with iron. In the paper that I read the other evening there is a table that is embodied in this which has simply to do with the costs of iron. That shows No. 1 foundry iron 1,800 lbs. tensile strength, at \$12 per ton. The total amount of iron is 92.49, but the metalloids are 7.51. That amount of metalloids has got to be eliminated in making steel and wrought iron. When we start in with the crude, coarse metal we have all these to act upon. The question of silicon is always a strong one. The value of pig iron is estimated by the amount of silicon in the metal. This is the commercial value. You put it there because it will carry more scrap and is therefore worth that much more to you. We have this question of metalloids now in addition. We have the question of the commercial value of metalloids as combined with iron in making castings. I hope to-night that you will all feel perfectly free in talking on the subject and that you have given a good deal of thought and consideration to the value of metalloids in making castings in your own personal experiences.

Mr. Ferguson: There is so much to talk about on this subject that I do not know where to begin. I would like to get a key for the starting point. It is some ten years ago that I first got interested in the properties of iron, and have made it a study more or less ever since, and in that time have had the use of a laboratory in connection with the work and I am only now beginning to know some of the values in connection with the use of metalloids. It is a hard road for the ordinary mechanic to travel to become familiar with the handling of metalloids. There are six or seven points that make all the changes. To me it seems a very delicate proposition to handle to get the desired results at all times. I would speak from my own experience of ten years of hard work and study, that I am only beginning to learn a little something. Therefore the members that have not had that experience must not become discouraged if they do not get the results that they are aiming at. It takes hard, close ap-

plication; and you cannot let go, you have to keep at it all the time.

The secretary read the following communication to a trade journal by Guy R. Johnson, in which the writer referred to some statements in Mr. McDowell's paper upon "The Influence of Metalloids:"

#### CARBON AND STRENGTH OF IRON.

I have read with a great deal of interest the paper of Major Malcolm McDowell, which was recently read at the Western Foundrymen's Association. Major McDowell's paper is very valuable, and the writer thoroughly agrees with him in saying that "iron should be bought and sold by chemical analysis." Granting, however, that iron should be purchased by chemical analysis, Major McDowell's views should have been expressed somewhat as follows: "In justice to both furnace and foundrymen, pig iron should be bought and sold by analysis, meaning by 'analysis' to include the carbons, as well as the usual silicon, sulphur, phosphorus, and occasional manganese."

As a matter of fact, the carbons would have to be included in the analysis of pig iron, if the iron were bought solely by chemical analysis; and still we should not have enough data to enable us to judge accurately of the characteristics of the iron. I am not saying this to discourage those who wish to see the foundrymen's business put on a more rational and scientific basis; on the contrary, I believe in such efforts, and have done what I could to help them along, being the manager of one of the furnaces to which Major McDowell refers, which make and sell foundry iron on analysis. I have found, however, that analysis will not do entirely; i. e., there is unquestionably so much influence exerted by the physical working of the furnace on the result of pig iron that it is necessary not only to have analysis, but also, for special work, to have the grade added. For instance, an iron for strong machinery castings, should analyze, according to the writer's experiments, about:

- 1 to 1½ silicon.
- .35 to .50 phosphorus.
- .75 to 1 per cent manganese.
- .03 to .05 sulphur.

Suppose, however, that this iron be made with the furnace working very hot, and consequently producing a graphitic iron, i. e., No. 1 or No. 2 iron. Does Major McDowell think that such a graphitic iron would give as strong castings as a No. 3 or gray forge fracture? i. e., an iron higher in combined carbon? If he does, his experience is totally at variance with that of the writer.

It seems to the writer that, while Major McDowell has given us some noteworthy results, he misses the main point when he attempts to explain the great strength which he arrives at in some of his castings. Take, for instance, his No. 1, which gives a total strength of 49,000 pounds to the square inch:

- Combined carbon, .93.
- Graphitic carbon, 2.19; total carbon, 3.12.
- Silicon, 1.34.
- Phosphorus, .08.
- Manganese, 1 per cent even.
- Sulphur, .003. (Should this not be .03?)

Now, let us compare them with a very similar Embreville iron, as to metalloids, with the exception of the carbons:

- Silicon, 1.29.
- Sulphur, .05.
- Phosphorus, .17.
- Manganese, .80.
- Graphitic carbon, 2.84.
- Combined carbon, .92; total carbon, 3.76.
- Tensile strength, 36,000 pounds.

There is no large variation here, with the possible exception of the sulphur, which element has a tendency, of course, to produce combined carbon, and which would tend to make the second iron the stronger. But between the total carbon of 3.12

and .376, there is a very large variation, and the writer believes that this is the key-note to the strength of iron; i. e., lower your carbons and you increase the strength of the iron; increase them and you decrease the strength of the iron. It is this reason that enables foundrymen who use an air furnace to make iron of a very great strength, because it enables them to burn out a very large proportion of the carbons, especially the graphitic carbon.

I quite agree with Major McDowell in his remarks on manganese, which has been a very much abused metal by many of our foundrymen. It might be recalled with profit by many of these that the famous Scotch softeners, without which, only a few years ago, many foundrymen thought they could not produce good castings, all contained from .80 to 1.25 manganese, and sometimes higher.

Mr. McDowell said in reply:

Cast iron is what it is because of the amount of carbon it contains, and the relation of the carbon to the iron, whether combined or uncombined, and the action of the two metals, silicon and manganese, and the two metalloids, phosphorus and sulphur, that affect these relations. A casting whose combined carbon is very nearly one-third of the total amount of carbon and two-thirds uncombined and these relations unembarrassed by the presence of phosphorus and sulphur, gives as strong a casting as can be made out of this grade of metal used. To demonstrate the truth of this I call your attention to the following statement of two heats of metal:

	Combined carbon.	Graphitic carbon.	Total carbon.	% combined carbon.	Silicon.	Phos.	Sulphur.	Mang.	Tensile strength.
Embreville iron .....	.92	2.84	3.76	25%	1.29	.17	.06	.80	36,000
McDowell semi-steel .....	.93	2.19	3.12	33%	1.34	.08	.03	1.00	49,900

When in a casting phosphorus is held below .20 and sulphur .05, their influence on high silicon castings is hardly perceptible; but when silicon goes below 1.40 an increase in the amount of

these metalloids is marked, not always so much in strength of the casting but its ductility, malleability and elasticity, qualities as desirable as strength. Had Mr. Johnson's metal carried 1.00 or over of manganese instead of .80 it would have increased the amount of combined carbon from .92 to 1.25 and his casting would have been proportionately stronger. Was this casting made from Embreville pig iron melted in a cupola or was it pig iron cast direct from a blast furnace?

When graphitic carbon makes itself manifest in an open grain fracture of dark color in pig iron, it is considered as evidence of the presence of silicon and is graded according to the fracture, No. 1 or No. 2 soft or No. 1 or No. 2 foundry and when the fracture shows combined carbon or a close-grained bright fracture, it is graded as No. 3 or No. 4 foundry. In each of these cases the pig iron is sold according to the fracture, but its value to the foundryman depends upon its constituent elements and it is immaterial to him how hot Mr. Johnson's blast furnace was that produced "graphitic iron." It may assist him in grading his output by fracture, but its value to the foundryman depends entirely on chemical analysis, not whether the fracture showed graphitic or combined carbon.

## PROCEEDINGS OF THE PITTSBURG FOUNDRYMEN'S ASSOCIATION.

At the February meeting, E. A. Uehling read the following paper:

### SANLESS PIG IRON.

"Necessity is the mother of invention," and the casting machine came into existence through sheer necessity, not to say desperation. Carrying the iron from the pig beds has always been considered the hardest task about a blast furnace, and blast furnace labor is all rough and hard. So long, however, as the output did not exceed 100 tons a day there was comparatively little trouble. But where is the furnace to-day the daily output of which does not exceed 100 tons? Two hundred tons is considered small. The general average daily output approaches more nearly 300 tons, 400 tons is nothing unusual, 500 tons per furnace has been exceeded by the most modern furnace plant, and 600 tons daily average will undoubtedly be reached by many of the furnaces in the near future. This, however, does not necessarily imply that such large output is necessary to produce iron at a minimum cost. There is no reason why a 250-ton furnace with a properly balanced equipment and economical management cannot produce iron as cheaply as one making 600 tons.

To handle such enormous productions by hand is almost impossible. But even with an output of 200 tons per day the laboring force to take the iron from the cast house is the most troublesome and the most expensive labor about the blast furnace.

No wonder that furnacemen have been racking their brains in the endeavor to contrive some mechanical means that would take care of the pig iron. Imagine yourself in the place of a poor furnace manager, who, forced by the small margin of profit to get out a maximum product, has been chasing about all day and probably half of the night to make sure of his stock supply, to keep up his heat, his steam, his engine revolutions, to get in the necessary cinder and iron cars, so as to be certain that there

would be no avoidable cause for interruption. Just imagine yourselves in his place being rung up at 3 o'clock in the morning to come to the furnace at once; and when you get there to find the furnace full of molten iron, both sides of the cast house full of pig iron, and the iron carriers also full. Something must be done and done quickly, for the furnace in that condition is liable to break out at any moment. To send for the day shift would be useless, for they were probably full, too. At any rate, it would be questionable that many, if any of them, would respond. They know it is very difficult to replace them. They can afford to be independent, and you must be thankful if they will be on deck to take care of the iron on their own shift. You call out the laboring gang. Every available man is put at iron carrying—and what a fist the majority of them make at it. It would be funny if it were not so serious. Meanwhile the iron is getting above the line of safety. It is liable to break out any minute. The flush of cinder just run had iron over and cut the monkey. You know from this that the iron will soon be getting dangerously close to the tuyeres.

Finally one side of the cast house is cleared. The beds are being molded up as quickly as possible, while the iron is being worried out of the other side. The furnace has already been held in two hours over time. You know that one side will not begin to hold all the iron. It is therefore necessary to prepare for a cross over. The cinder is now up to the tuyeres, the iron cannot be far away. You do not want to run another flush of cinder for fear of losing a lot of iron and cutting the cinder cooler also, the monkey having already been lost. You cannot take the wind off, because every tuyere would immediately fill with cinder and possibly with iron. The situation is getting more dangerous every minute. To facilitate matters you set the skimmer yourself, while the keeper isslicking up the runner and the helpers are molding up more pig beds. At last everything is ready, and the furnace is being tapped. You draw a temporary sigh of relief, for had the furnace broken out before the pig had been removed from the beds the result can be easily imagined. Although safely over the worst, you are not certain what will hap-

pen until the iron is all landed in the pig beds, and you are just beginning to tap. She comes easy, a few blows of the sledge hammer suffice to drive the tapping bar into the molten contents of the furnace. The bar is quickly withdrawn, and the liquid iron follows. The extraordinary head of iron in the hearth soon cuts the hole to double its proper size, the iron gushes forth and fills the runner to overflowing, and reaches the lower end of the cast house in a torrent. Two, three, four—yes, six beds have to be opened up simultaneously to manage the iron. Some of them overflow, sheeting the whole bed before the others are half filled. In the hurry to get the beds down the scrap had not been carefully sifted out and the cores were insufficiently tramped, consequently there is "jumper" after "jumper." The molten metal coming in contact with a piece of wet scrap immediately causes a boil. The liquid iron flying in every direction makes it impossible to open the beds adjacent, consequently you have to cross over before half the iron is out of the furnace. What this means must be experienced to be fully understood. Toward the end the flow of the iron becomes more controllable, but the rush of cinder is all the greater. The skimmer is washed away, and what had been saved from the boil and had not been spoiled by jump cores is deluged by a mass of cinder. Your eyes are red from the fumes, your face is blistered, your clothes are on fire, and over half the iron is a worthless mess. You do not swear. There are no words to express your feeling. The combined vocabulary of all the languages in the universe could not furnish appropriate words sufficient to do justice to the occasion. And all this on account of inadequate means for handling the iron produced and because the iron carriers got full.

Yet, looking at it from a disinterested standpoint, who can condemn the iron carriers for getting full. The work is such that you can hardly blame them for taking a day off—and it was pay day—the temptation was great.

The task of carrying pig iron is not fit to be performed by human beings. The extraordinary muscular exertion which is required bars four-fifths of the laboring class from standing up under the strain at all, and the necessity of passing back and

forth between the heat and the steam in the cast house and the chilly air outside is enough to kill a horse. It is furthermore a fact that similar messes, more or less serious, occur when the iron carriers are at their post. Every furnaceman is ready to admit that the old way of handling the iron at the blast furnace is entirely inadequate and cannot be continued.

From this apparent digression from my subject it is evident that there was ample incentive to blast furnace managers to invent a casting machine. Such a machine is desirable from a purely selfish motive, in order to save himself worry, trouble, annoyance—yes, even bodily injury. It is a necessity from a business standpoint, to do away with the most expensive labor and thus cheapen the product, and it is to be wished from a humanitarian point of view to perform by mechanical means a task too arduous to be performed by man.

There are probably few furnace managers who have not in their hours of trial, or shortly after, invented one or more ways of displacing the iron carriers. Most of these ideas born of desperation never took tangible form. A large number of contrivances, no doubt, got on to paper and were either abandoned as impracticable or the originators lacked the courage or the means to give their inventions a practical test. Not a few have been built and found their way into the scrap heap. But that is another story, which it would be out of place to discuss here.

It is only necessary to state that there now exists a successful casting machine which does all that can be desired, and that its advantages to the producer of pig iron are such that no blast furnace can afford to be without it.

In proof of this it will suffice to say that the casting machine at the Lucy furnaces, which has been in operation since April 3, 1897, had up to January 1 handled 163,497 tons of iron, 18,000 of which was spiegel. During all that time it did not miss a single ton of the output of the two furnaces. It was and is always ready to take the iron when it is brought to it. The machine at the Duquesne furnaces had demonstrated its capacity to take care of 1,200 tons of iron in 24 hours with ease. The cost of handling the iron at the Lucy furnaces, including all repairs to

the machine, ladles and refractory material, was 10.6 cents less per ton than that of handling it the old way, thus effecting a saving in labor cost of \$17,330.68 in nine months, or \$21,663.55 in a year.

The scrap made is less than 25 per cent of that made by the old way. Contingencies like those faintly pictured above cannot occur. The ladles are returned to the furnace as soon as emptied, and the furnace can be tapped whenever desired. There are no boils, no jump cores, no sheeted beds, there is neither scruff nor cinder on the iron. The pigs are uniform, smooth and clean. The labor required about the machine is so easy that it looks like child's play compared with the other work about the blast furnace. Not a pig of iron is touched by hand from the time it leaves the furnace until it reaches its destination or is piled on the stock yard. These are, in brief, a few of the advantages that will accrue to the producers of sandless (machine made) pig iron in which the consumer does not share. The advantages of sandless iron over sand pig in which producer and consumer share alike may be summed up as follows:

1. The abomination called the sand ton will be done away with. A ton of pig iron will be 2,240 pounds, and if it weighs that at the furnace it will weigh the same at the foundry. With it nine-tenths of the wrangling over short weights will disappear.

2. Grading by fracture will no longer be the basis of quality and price, and this will remove the most prolific bone of contention between producer and consumer of pig iron. The fracture of pig iron is a delusion and a snare. There is not one man in ten, whether consumer or producer, who can tell by the fracture a pig of iron suited for car wheels from one fit for stove plates.

At the furnace all foundry iron is graded by fracture. The pigs are broken in the middle and piled according to grade. As a rule, this is done as carefully as possible; but where is the line of demarcation between succeeding grades? What is the difference between an open No. 3 and a close No. 2, for example? No matter how carefully the grading is done, there must be, by the

very nature of things, in every grade, some pigs closer than others. There is therefore always room for contention, even when both sides are trying to be fair, which is not always the case.

The following episode has come within the writer's experience: A lot of No. 2 iron was shipped to a consumer. Before the cargo arrived at destination the price had declined 50 cents per ton. When the date of settlement came, instead of the proper remittance, there came a long letter of complaint, stating that the iron was not up to grade, that fully 50 per cent of it would not go better than No. 3, and that a reduction in price must be made on the iron equal to the difference in the market value between the grade sold and that actually shipped—viz., 50 cents a ton. The case was worth investigating. When the furnace representative arrived, he found a lot of samples of the iron in the office awaiting his inspection. The iron was from the lot, there was no doubt of that, and the grade was not better than an open No. 3. He knew that straight No. 2 had been shipped, so closer investigation was necessary. He went to the pig iron yard. The attendant furnished by the customer broke a lot more of the half pigs, with the same result—an open No. 3 at best. But the furnace representative happened to be equal to the occasion. He helped himself to some of the iron and broke it, and to the pretended great surprise of the purchaser nearly every pig showed a fracture much nearer No. 1 than No. 2, and the iron was accepted as sold. The fact is that nearly every pig of iron varies in grade from one end to the other. Not infrequently you can show up three distinct grades in one and the same pig. The sow, if at all heavy, is invariably from half to a whole grade higher than its pigs. Is the iron in the sow therefore of a better quality? This is hardly reasonable, yet you pay from 50 to 75 cents more for it.

The value of an iron does not depend upon its fracture, nor is the fracture any guide as to the special purpose for which a certain iron may be best suited. It is an indication of the condition of the furnace that produced it, and not an altogether reliable indication of that even. The principal factor that deter-

mines the grain in the fracture of cast iron is the time given it to pass from the liquid to the solid state. No one is better aware of this fact than the foundryman. Of two castings poured from the same ladle, the lighter casting is invariably the closest grained. The degree of hardness resulting in a casting is not determined by the fracture of the pig; but entirely by its chemical composition and the rate of cooling. No. 1 iron may be fitted for car wheels, or it may be suited for stove plate, or it may be useless for either. How many can tell what it is suited for by the fracture? No. 1 iron may contain anywhere from 0.5 to 3.5 per cent. of silicon, and the other elements with the exception of carbon may vary in the same proportion.

Experience has taught the practical foundryman that certain brands of iron are best suited for a certain class of work. He ascertains this by trying first one and then the other, and then several brands in combination in varying proportions, until he gets the right thing. When he has it, he sticks to it. Everything goes smoothly for a while; but suddenly something gets wrong. The castings come out hard or lack strength, too much shrinkage, full of blowholes, cold shots and what not. What is the trouble? The same brands, the same grades, the same mixture. No change at all, yet there must be something the matter with the pig iron, and it must be in that last shipment, of course. There was no trouble until it was put on.

It is thoroughly investigated, and sure enough the lot contains pigs with close edges, others with dense spots, and more with irregular grain. The iron is not up to grade anyhow, and the whole shipment is condemned. If the price of iron tends downward the producer is in for all or at least part of the damage. With a stationary market it is a toss up, and on a rising market the consumer pockets his loss. In reality the chances are at least even that the trouble was not from the iron at all. There are as many chances as there are brands of iron in the mixture that the wrong brand was condemned. Nine times out of ten it will be used up later on and give the best results. Making up mixtures for special purposes, depending solely upon the fracture to guide you, operates on the same principle on which the

Irishman got the weight of his hog. He selected a log with great care, balanced a plank very nicely across the log, laid the hog on one end of the plank and piled stones on the other end until it was accurately counterbalanced, and then he guessed at the weight of the stones.

The condition of the sand in the pig beds, the rapidity with which the iron fills the beds, the size of the pigs, are all factors that greatly influence the fracture. If two pigs lying side by side in the same bed happen to be of unequal size, the larger will invariably be of a higher grade than the smaller. If the large pig is No. 1 the small one may not show better than No. 3. Has the quality suffered because the mold was not run full? Yet this pig, with many others whose fracture suffered from similar causes, goes to the No. 3 pile, and brings 75 cents less per ton.

The reverse also holds good. By proper coaxing a No. 3 can be elevated to a No. 1, and in order to please the consumer who buys on fracture the producer does all the coaxing he can, by making the pigs large, covering them up with sand, providing a third casting bed, etc., to give all the time possible for the iron to cool. Except in very wide limits the fracture of pig iron is simply something to guess the quality by. It is the pile of stones that counterbalance the Irishman's hog—it is something to quarrel about, and the sooner grading by fracture is abandoned the better for all concerned.

Chemical composition is the only true guide by which iron can be intelligently judged as to its quality and fitness for the purpose in hand. Chemistry in the foundry is still in its infancy, and much is yet to be learned. But with foundrymen's associations established all over the country, composed of intelligent and energetic workers in behalf of the practical application of scientific principles, the advantages of chemical analysis as well as synthesis are beginning to be more generally understood and appreciated, and it is only a matter of time when its benefits will be fully realized. The greatest drawback to the practical application of chemistry in the foundry is due to the fact that with iron cast in the sand in the ordinary way it is almost impossible to get shipments of uniform composition. This is due

to the fact that the iron as it flows from the furnace is very irregular, and it not infrequently happens that there is a difference of 1.5 per cent in the silicon from the first to the last bed in a cast of iron of practically the same grade.

The last, but not least, mutual benefit that will be derived from the use of the machine for casting sandless foundry iron will be due to the fact that it will not only be possible but very easy to furnish iron of uniform composition. The iron of each ladle containing 15 to 20 tons will of necessity be uniform, and can be easily analyzed and piled or shipped according to analysis.

We now come to the advantages that sandless pig iron will have for the consumer alone: 1. I am authorized to say that in the basic open hearth furnaces at Homestead where all the iron produced by the Lucy furnaces has been consumed, sandless pig iron has been demonstrated to be worth at least 50 cents a ton more than sand iron of the same composition. This enhanced value is due first to the fact that it melts more readily than iron with a crust of sand about it, and is in a more advanced state of reduction when melted. Hence it is more quickly converted. 2. The sand damages the hearth, and requires additional flux. The sandless pig is harmless, and the flux required is a minimum, thus saving material as well as wear and tear. 3. In consequence less fuel is required to convert the sandless pig into steel. 4. This results in an increased output.

The same holds true in remelting in the cupola for Bessemer steel. The sandless pig requires less flux, less fuel, melts more quickly, and results in appreciably less wear and tear in the cupola. No systematic tests have as yet been carried out, but the advantage of the sandless pig iron is easily estimated at 10 cents per ton.

From this I feel warranted to draw the inference that a similar saving, though possibly, owing to the intermittent work, less in degree, should result with sandless iron in the foundry cupola.

The results obtained by Thos. D. West, which were presented at your last meeting, indicate clearly that there is less oxidation from clean iron than from iron cast in the sand, otherwise of identical composition. The average of Mr. West's experiments

showed the loss by oxidation in remelting sand iron to be 5.5 per cent, while the loss in sandless iron was only 3.4 per cent. Taking pig iron at \$10 a ton the loss on the sand iron would be 55 cents, against 34 cents on sandless pig—a clear gain in favor of the machine iron of 21 cents per ton. These results will require corroboration on a larger scale before they can be taken as absolute, but they indicate what may be expected.

The sandless iron melts quicker and with less fuel than the sand pig. It is less liable to be contaminated by the impurities in the fuel. It will require less flux, and will make a cleaner casting. In short, the indications are that it will prove in every way superior to the sand pig for foundry use.

## PROCEEDINGS OF THE NEW ENGLAND FOUNDRYMEN'S ASSOCIATION.

At the February meeting of this association J. A. Caldwell, M. E., read a paper entitled "Some of the Advantages of the Positive Pressure Blower Over the Fan for Melting Iron," from which we reproduce the following:

One of these advantages is that the blast is positive and that it positively and aggressively goes to its appointed work of furnishing one of the principal ingredients for the melting of the charge, independently of the ever changing conditions in the cupola, as against the unreliable character of the blast from the fan, which has nothing positive or certain about its action.

The makers of the positive blower claim that since each pound of fuel burned requires an absolute measure of air for its complete combustion, whether in a cupola or anywhere else, that the means of getting that air to the point or zone of combustion should be as absolutely fixed and certain as mechanism can make it.

The law of combustion is, of course, a law of nature and not the dictum of this or that blower manufacturer. Prof. Thurston, an acknowledged high authority on the subject, states that perfect combustion occurs only when all of the combustible is burned, and with the result of (or in conjunction with) producing the highest stage of oxidation, which can only be reached by the use of a proper proportion and application of air.

Theoretically perfect combustion is—perhaps unattainable in the arts, but the physical laws for producing and maintaining a high rate of combustion or temperature are known as well as mechanical steps necessary to attain such conditions.

Cupola practice is really a system of what in other branches of mechanics' arts is termed "forced draught," and James Howden, the greatest living authority on the subject of forced draught, states that for 12 pounds of coal burned on a square foot of grate per hour, there should be provided 22 pounds of air, or 286 cubic feet for each pound burned, and for 16 pounds

per square foot per hour 312 cubic feet, and for 20 pounds 364 cubic feet. Thus we see that the faster the process of combustion is carried on the more air is required per unit of fuel, and we also see the necessity of having the means at hand that will insure the air getting to its destination.

When the proper quantity of air is supplied, each atom of carbon (of which the coke is almost wholly composed) meets its corresponding atom of oxygen, and a high state of combustion ensues. When, however, a sufficient quantity of air fails to reach the cupola, the carbon, being changed into its gaseous state by the surrounding heat without meeting its corresponding atom of oxygen, is carried out unconsumed, thus entailing heavy loss, amounting under certain conditions to as much as two-thirds the total heat power of the fuel.

It can easily be seen why the positive pressure blower is superior in this regard to the fan, delivering and forcing forward as it does a fixed and definite quantity of air at each revolution under all conditions of the cupola, so that commercially perfect combustion results.

If it were a fact that a cupola called for less blast in exact proportion as resistance increased, and more blast when everything was free and open, then the fan would be the ideal machine, furnishing, as it does, such conditions automatically and without external regulation; but when the reverse is exactly the case, and even more air rather than less is demanded when the condition of the stock causes unusual resistance, then the fan fails to supply it, just as fans are at their best when least pressure is required. Like a horse that had a habit of backing the moment his feet touched the foot of a hill to be ascended, and beginning to pull as soon as the wagon struck the descending grade, we would say of such a horse "it is a pity he did not pull going up hill and do his backing while going down hill." And so we say of the fan. But the fan keeps on year after year doing its best (under strong protest) to meet conditions forced upon it that it was never meant by the laws of mechanics to fill, and when its honest efforts to raise the wind are opposed it simply beats the air with its wings, much as a tethered eagle would do

that tried to soar beyond the reach of his chain. The reason of this is, of course, because the blast from a fan is due to the centrifugal force of the air sliding, so to speak, off the revolving blades, and when that radial and tangential delivery is obstructed by closing the outlet or discharge opening, the fan continues to run as before, carrying the air around with the blades but no blast being discharged, and if the resistance is only partial then the volume of air from the fan diminishes in the same ratio as the resistance, till a point is reached when the momentum of the radially driven air and the resistance are equal and no air whatever is discharged. Of course the wheel or blades continue to revolve with great rapidity and absorb a large amount of power while doing no work at all.

It is not strange that this very glaring fault in a fan's action is constantly being lauded by its makers into the dignity of an estimable virtue. It is called the safety valve action, the automatic relief and so on, but it partakes of the kind of relief we have all experienced at a church fair. It is a delightfully easy way of getting rid of any objectionable heaps of coal that may be lying around loose, the larger the heaps the better; in fact, it takes from 35 to 40 per cent. of the power required to do full work to run the fan blades at the same speed with the discharge opening closed down and of course no work at all being done.

But the explanation offered by the fan advocates that "hardly any power is required," when the fan is running thus is one of those fictions that is a good selling thing and gets pushed along unquestioned for all it is worth until it comes to pass current as Gospel truth.

The real fact is that of all faults inherent in the fan, this so-called automatic relief action, which proves so costly a luxury in fuel, is the one of all others its advocates would like best to get rid of, and fame and fortune surely await the lucky inventor who can at one bound eradicate this fault and thus make the fan into a positive pressure blower that would sell at the same price at which it now sells. As the case stands at present no certainty of action can be predicated on the operations of the fan, as the volume of air is varied by every contingency that arises to vary

the resistance within the cupola, and as for emergencies calling for more than the usual pressure, they cannot be met, and we all know that in hundreds of instances the charge has to be dropped. A few weeks ago I was in a foundry when this had happened a number of times, including only the day before.

With the positive pressure blower all this is different, since each revolution, running slow or fast, means a fixed amount of air forced forward, an amount which is not altered whether the resistance becomes greater or less, and in an emergency when more air is needed it is but the turning on of more steam, as often happens in blast furnace practice, and indeed with all mechanico-chemical industries.

In this connection a most valuable point should be noted. That is, the saving of time effected by using a positive blower. It will be at once admitted that if the fuel in the cupola can be properly consumed, a very much greater heat will be generated, preventing dull iron and slow melting. Therefore, with a given size cupola a larger amount of iron can be melted in a given time. This enables the foundryman to turn on his blast at from one-half to an hour later than when using a fan, giving him this extra amount of time for his men to mold, greatly increasing the amount of iron melted. The saving that this point alone makes in the average foundry in a year, goes far towards paying for the cost of the positive blower over the fan.

Again, soft and fluid iron can only be secured by perfect and uniform combustion in all parts of the cupola, rapidly melting the iron and getting it under the slag, where it is protected from the action of the blast, and consequently from being decarbonized. If the combustion is imperfect around the walls of the cupola, then the iron is exposed for a long time, in a mushy semi-fluid condition, to the action of the blast, and rapidly decarbonized, converting it into steel. Thus a similar process is carried on in the cupola, as in a Bessemer converter. This iron, as it slowly melts and drops down into the melted iron below, makes either hard spots in the castings or deteriorates the whole, as it is more or less mixed with the mass. A further result of this condition of things is that the iron having parted with its carbon, loses its

fluidity and will not run or fill the molds, causing imperfect castings. When these things are properly understood, the importance of having a positive blower will be realized. The blower is the lungs of the foundry. A good blower is fundamental to the highest degree of success, and the small amount saved in the difference in first cost between a positive blower and a fan is dearly paid for in the losses that follow.

A second advantage is that the fan requires to be run at ten to fifty times the speed of the positive pressure blower. It is easy to simply say "ten to fifty times faster," and pass it over without thinking much about it, but anyone that has had to do with fast running machines of any sort knows what he has to endure in the way of burnt bearings and broken belts, in fact, the usual enormous wear and tear incident to such machinery under ordinary conditions so commonly met with. In hundreds of cases the exasperation from these experiences alone have resulted in telegraphic orders for positive pressure blowers. The fan might be compared to a horse running a mile in two minutes liable to stumble at a mere straw in the way, while the positive blower might be compared to the good old steady draught horse that can always be relied upon.

## A REVIEW OF THE FOUNDRY LITERATURE OF THE MONTH.

### IRON TRADE REVIEW.

A. E. Outerbridge, Jr., asks "Is Manganese a Metalloid?" and answers the question as follows:

The modern scientific literature on the subject of cast iron is assuming such important proportions that it would seem very desirable to prevent erroneous terms from creeping into it and becoming established therein.

It appears to be the universal custom of such writers to-day to assume that all of the elements found in cast iron, except the iron are "metalloids," not metals. It is, therefore, I think pertinent to ask, What are metalloids? According to the classification of Berzelius, one of the great fathers of chemistry, the term metalloid is strictly limited to "inflammable, non-metallic elements." Manganese clearly does not come within this definition, for it is not inflammable, and it is a metal. One of the accepted distinctions of chemists between a metal and a metalloid is that of "specific gravity," the metalloids being of very low specific gravity, while the metals, as a rule, are comparatively dense. Manganese is heavier, bulk for bulk, than cast iron, and in all chemical classification with which I am familiar, it is known as a metal, never as a metalloid. When alloyed with copper, in the form of "manganese bronze," the manganese still remains a metal, and even when alloyed with iron, in the form of "ferro-manganese," it is recognized by metallurgists in all steel works as a metal. Yet, by some strange and inexplicable process, this same metal manganese, alloyed with iron (ferro-manganese) when powdered and melted in a ladle of cast iron, or even when melted in a cupola with the pigs, loses its identity as a metal and becomes known to the foundryman or to the foundry chemist as a metalloid! By what authority has the change been made?

The most liberal classification known to chemistry includes 13 metalloids, but manganese is not of the number: they are as follows: Oxygen, hydrogen, nitrogen, chlorine, carbon, bromine,

iodine, fluorine, sulphur, selenium, phosphorous, boron and silicon.

It will be observed that silicon is included in this list, but I am prone to believe that it is more likely to be regarded in a future classification as a metal. Ferro-silicon, for example, is a metallic alloy of iron and silicon, having high specific gravity and a high melting point. Until recent years silicon had not been isolated and even yet but little is known of its properties.

The chemist invariably makes his return of silicon in cast iron by subtracting the proper equivalent from the weight of silicic anhydride ( $\text{SiO}^2$ ) found in his platinum crucible after burning off the carbon. If the weight of the  $\text{SiO}^2$  found is equal to, let us say, exactly two per cent of the cast iron, he reports the silicon content as 0.93 per cent (or to be precise, 0.9334 per cent).

While I do not presume to criticise the accepted classification of silicon as a metalloid, I feel quite confident that chemists will agree with me, when the matter is called to their attention, that manganese is not a metalloid and should not be classified as such in foundry or other chemical literature.

#### THE TRADESMAN.

Referring to "Center Blast" for cupolas, Mr. West says: We are using it at our foundry, melting daily 60 to 70 tons of pig metal, out of a 66-inch cupola, that previous to our adopting "center blast" took us from one to two hours longer to run off our "heats" than it now does, and at that time three cars of coke were necessary where two now answer. Aside from this there are other benefits that I will not take space to mention. The fact of our saving about \$50 per week in fuel by the adoption of "center blast" is alone sufficient to cause us to advocate its utility. In first experimenting with "center blast" some loss is liable to be incurred. This quality I have always advanced in my writings, and again have stated that there are cases where its application is not practical. Owing to these two conditions, some late parties claiming to know everything about founding, and considering a sale of "center blast" appliances of more importance than a reputation for being practical have greatly injured its introduction.

For a thoroughly practical founder well experienced in cupola practice that could travel for the introduction of "center blast" there is a good thing. If such a man would come to me, I would take pleasure in seeing that he had all my experience, and was started out well fortified with necessary knowledge to successfully inaugurate "center blast" in shops, where its application was practical. I would do this for two reasons; the first is owing to the pride I have in being, as I claim, the originator of practical "center blast," and, second, because of the abuse it has received at the hands of impractical men trying to introduce it.

Partly as a reply to the above, E. H. Putnam writes: "The center blast as opposed to outside blast in cupolas of medium and smaller diameter is entirely wrong in principle. A blast of constantly waning power as a supporter of combustion being diffused into a constantly expanding area cannot be else than wrong. Whereas, the fresh blast entering the cupola at the circumference, and passing into a constantly diminishing area as its power declines is, it seems to me, the natural and proper thing."

"Briefly, then, to use auxiliary center blast in a cupola whose diameter is so great that the circumferential blast becomes too much exhausted before it can reach the center, is rational. But, to use it in all cupolas because it is profitable in the larger ones would be, in my opinion, carrying the practice to an unwise extreme. To be more explicit, I do not think that center blast would be profitable in cupolas of, say, 46-inch diameter, and under. Very few have found it else than disastrous in cupolas of any diameter. But Mr. West explains this as the result of incompetency in management. If future manipulation shall make it generally successful no one will record the fact with greater pleasure than the writer."

In the issue of February 15 Mr. Putnam, referring to the paper on "Molding Sand," read by Mr. Truesdale at the Cincinnati meeting of the Western Foundrymen's Association, writes as follows:

It is no new thing to mix free sand with clayey sand for molding. Indeed, it is a very common practice to modify the quality

of molding sand by adding sharp sand in order to prevent blowing and scabbing. A few years ago we began the manufacture of sugar kettles in the shop where I was then engaged. These were cast bottom down, of course. The first kettles made had numerous small, thin scabs on the face. A liberal addition of free sand entirely cured the trouble.

In casting heavy pieces, such as drop-hammer, dies, etc., it is important that the mold be very hard rammed to insure against the least swell. If the sand in use be a little too fine to stand such ramming, add 25 per cent of coarse, sharp sand in the facing and you will be safe.

It is not necessary that all the sand of which the mold is composed shall be coarse and porous. The facing is what decides the matter—that is, if the molder understands his business. If the facing is sufficiently porous and the mold is properly vented down from the outside to the layer of facing, all will be well. Whether the facing be made by the admixture with the sand of coal dust or of free sand, one of the objects in view is the same, viz., to produce porosity in order that the expanding steam and gas may pass freely to the vent holes, and so out of the mold. This statement may appear superfluous to most practical foundrymen, but there are some who need this advice.

That free sand will produce a clean face on the casting is well known. Pig iron cast in free sand molds will be almost entirely sand free. The more refractory the material of which the mold is made the cleaner will be the surface of the casting. But ordinary free sand is of such coarse grain that enough cannot be used in its natural shape to operate as an effective and complete facing. It is for this reason that the silica, ground fine, is more effective. The free sand, if used in sufficient quantity, would not retain its form in the mold, but the silica finely ground will lie in the sand with which it is mixed in such manner as to be thoroughly bound by the more clayey molding sand, and so an almost unbroken face of silica may be presented to the iron.

Guy R. Johnson writes a short article on "Chemistry in the Foundry," from which we take the following:

I simply wish to say, as far as our foundry contracts go here, that we cannot do without the aid of chemistry. Possibly one or two examples would not come amiss: We have one or two large contracts which call for the making of special castings, such as rolls for rolling mills, both chilled and sand, besides other special work of that sort. Now, if we had undertaken to find out by the cut and dry method what iron was necessary to make a chill of say one inch, on chilled roll, I fancy that we would have been a good while in obtaining it, besides being put to considerable expense. As it was, by referring to the writer's records, which have been kept for several years with great care, in respect to analyses of different castings, it was possible to pick out a combination of two irons from the casts on the yard which gave the chill perfectly without experiments. In the same way, in making heavy sand rolls, we have very little difficulty in arriving at the proper mixtures to give a very strong, close resultant casting, capable of taking a very high polish and of great tensile strength.

We are also makers of car wheels for use in mines, etc. These we chill, and we have no difficulty whatever in getting just the depth of chill which is required by going to our stock pile and taking out an iron, which we know by the analysis will give the proper chill. The same remarks apply to making plow points, rolls for flouring mills, etc., etc.

As far as the vexed question, "What makes iron chill?" goes, I am afraid that I don't agree with Mr. Putnam, when he says that "two irons may analyze identically the same, and one will chill and the other will not." This is at total variance with the experience of a good many years, because everyone knows that the result of running molten iron against a cast iron chill, is to make the carbon in the molten mass next the chill assume the combined state. Now, if the molten iron be a high silicon iron, it will not chill; also if it be a low silicon iron, with high sulphur contents, it will chill much more deeply than the same silicon content with a lower sulphur; in other words, silicon acts to cause the carbon in iron to assume the graphitic form; it is, however, largely neutralized by sulphur; some writers claim in the proportion of 10 to 1 of sulphur.

Now, it is usually a very simple matter for any foundryman, buying iron of guaranteed analysis, to make a few experiments for himself. He can then tell just how much each iron will chill, and by keeping the record he will never have any difficulty in the future, as long as the other conditions remain the same, in getting the same chill from the same analysis.

E. H. Putnam, in "Some Points in Foundry Practice," writes:

People sometimes say, "It's all in knowing how." But this is an exaggeration. It is not all in knowing how. The people who know how to do right in general matters greatly outnumber those who know how, and who act up to their knowledge. One must not only know how, but he must have the force of character to impel him effectively to do accordingly in order to the highest success. This truth applies very forcibly in iron founding. How often we see a man pour a mold when he ought to know that there is not sufficient iron in his ladle for the cast. Some men are so insufferably foolish in this particular that they will take the most desperate chance with a mold that may have occupied several hours in the making. This will hardly do in a molder—it will not do at all in the foreman. He must know how to do, and he must do as he knows how.

I have seen many cases of indifferent success in the conduct of foundries where strict attention to a few important principles would have made all the difference between failure and success. And in hope to help somebody a little, I will advert to a few points in iron founding that must never be neglected:

First, last and all the time, the cupola. The cupola, it has been well said, is "the heart and lungs of the foundry." If you doubt this, do not take a foremanship. If you know nothing about molding and all about the cupola you can manage a foundry tolerably well; but if you are the best moulder in the country and are ignorant concerning cupola practice, you are absolutely unfit to manage a foundry. True, you may have the good fortune to get charge of a foundry where the melter is both competent and faithful. In such case you may never discover your weakness till your melter quits. But I advise you to take lessons in melting before such a catastrophe shall befall you.

In the first place, the molder will not know how to do his work if the quality of the iron is not practically uniform. Suppose you are making light, thin castings, difficult to run except with hot iron. Now if on some days the iron be all right, while on other days it is dull, the molder will be apt to pour too hard with the hot iron, and too slowly with the dull iron. The reason for this is plain. He loses work from dull iron, and determines that he will pour faster next time. But now it happens that the iron is pretty hot, and therefore the castings are strained, and many of them ruined. He sees plainly enough that he has made a mistake in pouring so fast, and assuming that the iron is all right next day, he may gauge his pouring about right, and so saves most of his work. But again, in a day or two there is a dull heat, and in his uncertainty as to how to handle the execrable iron, he pours some of it too slowly, and the castings don't run; and some of it is poured so fast that the castings are strained, or the iron bursts out from the flask.

The incompetent foreman charges the loss to the molder. This is an outrage, but it has to be, for the foreman dares not confess his own incompetency, and the molder thinks it better to bear injustice than to lose his job.

#### AMERICAN MANUFACTURER.

Wm. B. Phillips contributes the following article to this journal on "The Southern Iron Market":

The effort now making by some of the principal iron producers in Alabama to steady the iron market is a step in the right direction.

The current quotations at Birmingham are as follows:

No. 2 S.....	\$7.25
No. 1 S.....	7.50
No. 1 F.....	7.50
No. 2 F.....	7.25
No. 3 F.....	7.00
No. 4 F.....	6.50

G. F.....	6.50
Mottled .....	6.50

These prices might be shaded on good orders, particularly if accompanied by the cash.

This is now the second attempt during the last three years to steady prices by refusing to make concessions. The first agreement was carried out for a while, but for some reason or other finally came to nothing, and the field was free to all comers, and they did not fail to come. The result was that during the last year prices while nominally at such and such figures really fluctuated according to the circumstances of the order.

The 218,633 tons of pig iron exported last year from Alabama certainly acted as a check-valve, and it is quite possible that such steadiness as was enjoyed by the market was due in great measure to the foreign shipments. Steadiness of price, even if that price be low, is a great deal better than fluctuations in price, even if they bring it much above the average. If, therefore, the principal producers here can agree among themselves that they will "tote fair" a great advantage will be gained. But this was agreed upon three years ago. What has brought about the present stir? Is it that the former agreement has lapsed through the course of time, or that some recalcitrant has not lived up to it? It is doubtless a good thing to get together and agree as to what the price shall be for the various grades, but unless there is at the same time an agreement as to what kind of iron shall be classed in the grades, of what earthly use is the other agreement? The producers may come together, and all solemnly and a few piously agree not to sell any of the grades below a certain price. So far so good! The prices are established, and we will suppose are rigorously maintained. Very good. Pretty soon there comes along a customer who wants 1,000 tons of No. 2 foundry. The price is \$7.25. He asks for an analysis. It is made for him, and he finds that according to the analysis the iron would grade as No. 3 F., price \$7, or as No. 4 F., price \$6.50. What is the result? He buys it for No. 3 F. or No. 4 F., on analysis, but on the yard it is graded as No. 2 F. He gets at the price of No. 3

F. or No. 4 F. what appears on the yard and on the books as No. 2 F., and everybody is satisfied. The seller has not violated the agreement, because the iron is really not No. 2 F. at all, and in the absence of an agreement as to what shall constitute No. 2 F. he is at liberty to do as he pleases.

When people agree to sell at a certain fixed price a number of things whose quality depends absolutely upon the composition, and do not at the same time arrange for the grading according to composition, they cut two holes in the door, one for the big cat and the other for the kitten.

I do not know it to have been the case, and therefore I do not assert it, but it seems to me that some such snag must have been encountered by the agreement of three years ago. Because iron is said to be No. 2 F. is no reason for supposing that it is so, except, perhaps, by those whose implicit confidence in the truthfulness of humanity has not been marred by untoward experiences.

I do not believe that there is a single iron producer in Alabama who would certify to a shipment as being No. 2 F. when he knew it was not. It is graded on the yard by men who are supposed to know their business, and it is shipped according to their opinion. As to what it is really that is left for the consumer to ascertain. With a reliance upon the oversight of Providence which is most beautiful to observe the shipper bills his iron, and then gets his typewriter in order to fight against reclamations for off-grading. Between his firm trust in Providence and his profound distrust of consumers, he has rather a lively time of it. When will our people come to see that the yard grading of pig iron is rapidly passing away, and that the sooner it is gone the better? They may make all manner of agreements as to prices, and endeavor to maintain them conscientiously, but until these solemn compacts are based on something else than the judgment of the yard grader, prices will be cut. It is inevitable. The purchase of iron on analysis may not at present be much in evidence as regards the mill, foundry, and pipe trade. But even here the tendency is strongly towards the more scientific and the more satisfactory system of chemical inspection. When we remember that the application of chemical knowledge to the making of iron and steel

in this country goes no farther back than 1865, and reflect upon the wonderful improvements of the last 30 years, we are amazed that so much has been done in one direction and so little in another. As regards chemical and physical tests, the steel trade is a long way ahead of the foundry, the mill, and the pipe trades. One of the chiefest reasons why the southern iron trade has not taken kindly to the sale of iron on analysis is that southern iron goes to foundries, mills, and pipe works, and not to steel works. It was not until 1895 that any respectable amount of southern iron went to the steel maker, and although the sale of basic iron has been the most distinguishing characteristic of the southern domestic iron trade during the last two years, yet the quantity of iron used for steel making is comparatively insignificant.

Agree on prices, by all means, but if there is not underneath the grading a more reliable method than the one now in use, it will be labor thrown away.

#### THE FOUNDRY.

D. C. Thompson illustrates how he built an up-to-date brass furnace from such patterns as are found in the majority of jobbing shops.

Archer Brown, of Rogers, Brown & Co., writes of his observations throughout Europe. The following paragraph from Mr. Brown's letter shows that the Europeans strangely resemble a few manufacturers on this side of the water:

One noticeable thing is the air of mystery and secrecy with which most foundries surround all their mechanical operations. The impression is given that each one is manufacturing by some secret process which none of the others enjoy. High walls are built about the works and every avenue of approach guarded with great care. When you ask the natural questions as to class of work made, the kind of iron employed, manner of mixing, etc., the answers are as vague as those of the Delphic oracle. One would think that the making of ordinary railroad castings, for instance, was a secret handed down from the fathers and grandfathers. It is but just to say that in the largest and most progressive concerns this somewhat antiquated wall of mystery is

taken down, and the intelligent managers talk frankly and are open to suggestions.

E. J. Baker, foreman of the Northwestern Wire Mattress Co., at Kenosha, Wis., writes of a novel cupola practice at that place. We reproduce part of his letter herewith:

Our cupola is a Whiting No. 2½, 41-inch shell, height of charging door from tap hole 9 feet 6 inches, number of tuyeres 6, 2 lower and 4 upper; lower tuyeres are 18 inches from the bottom while the upper tuyeres are placed 15 inches higher. The cupola is lined with two courses of brick, and an additional lining of sand, rammed firmly around a tapered plug, 14 inches at bottom and 17 inches at top. Our object in lining the cupola to such a small diameter is to save coke, and is also made necessary by the fact that we need a steady quantity of iron throughout the day instead of a larger amount in a few hours. We have no set quantity to melt, as changing conditions, frequently occurring throughout the day, have to be met by a corresponding change in the cupola practice. The class of work we manufacture is small chill castings, the largest not exceeding four pounds in weight. As all of the iron is taken away in hand ladles, holding from 30 to 35 pounds, and has to be carried up to about 90 feet from the cupola, it is an all-important point that the iron shall be hot, as it must be poured very slowly, otherwise the result is a blown casting.

Our practice is to start the fire in the cupola at 4:30 a. m. with from 250 to 300 lbs. of coke on the bed, on which is charged from 100 to 125 lbs. of pig and 300 lbs. of scrap. The blower is started at 6:30 a. m., the following charges being made up of 30 lbs. coke, 100 to 125 lbs. pig and 400 lbs. scrap, with from 15 to 25 lbs. of limestone to each charge. The slag is removed, as fast as accumulated, through the slag hole, which is kept open all day. At noon the tap hole is knocked out large enough to allow the remaining slag to be blown off, when the cupola is filled up with coke, from 250 to 300 lbs. being required to put it in condition to receive the first charge following the noon hour, after which the practice of charging is the same as already explained

of the forenoon. We melt until 6 p. m., when, instead of dropping the bottom, as is usual, we knock out the breast, which is built of coke and sand, having a plate and strap to hold it in position. This part of our practice becomes necessary owing to the small diameter of the cupola. The sand bottom is heavy and built steep so as to run the iron directly to the tapping hole.

Someone propounded the following question to Mr. Keep:

"One of our main branches is pulley castings and we have considerable trouble in obtaining a proper mixture that will make a strong, and at the same time a soft, casting, particularly in pulleys having rims of light weight. Our mixture is Southern No. 1 soft, Ohio foundry iron, and machinery scrap. Our pulley castings vary in weight from 10 to 10,000 pounds each, the majority being less than 100 pounds. We would like your views as to the best mixture of iron for pulley castings. We have been experimenting with aluminum for some time, but cannot see that we have derived any benefit from its use. Will you kindly tell us whether its use should be of benefit in such castings as ours and in what way aluminum will act on a mixture?"

Mr. Keep answers as follows:

If the cast iron which you use contains a large proportion of combined carbon the addition of aluminum will change a part of it into graphite. The adding of a small portion of aluminum will have very little effect. The fact that adding aluminum to iron which tends to be white, will make it gray, and will take out brittleness, does not prove that it would be desirable to use it in ordinary foundry mixtures. Silicon added to cast iron exerts exactly the same influence as adding aluminum, only a greater quantity is required. Aluminum is expensive, and there are practical difficulties attending its introduction which makes its use impracticable. Silicon can be purchased in pig iron without materially adding to the cost and there is no difficulty in adding the necessary amount to the iron mixture. The addition of either to a mixture which is already gray and soft enough cannot improve the casting, and will very likely make the grain too open and therefore weak.

The shrinkage of all parts of a casting should be as nearly as possible the same, which can only occur when all parts of all castings poured from that iron are of the same size. It is usually conceded that it should be as nearly as possible to one-eighth of an inch per foot.

To make a large casting shrink one-eighth of an inch per foot it must contain less silicon than if the casting was small. This makes it a difficult matter to produce a uniform shrinkage in a pulley which has more iron in one part than in another.

The iron in any one casting must contain the same silicon whether in the heavy or the light parts, therefore the thin parts will shrink more than the heavier portions, causing unequal strains.

When such unequal proportion cannot be avoided iron that will shrink least will be most likely to produce a casting which will not crack and which will have the smoothest surface. Generally speaking, any pig iron that will produce a casting with the most desirable percentage of silicon is not only the cheapest, but the best; although it is a fact that certain brands of pig iron will produce exceptionally strong castings, while other irons which have the same chemical composition will not produce as strong castings.

The fact that aluminum changes combined carbon to graphite and acts in the same manner as silicon, was first discovered in 1888. (Trans. A. I. M. E., Vol. XVIII., pp. 102, 799, 835.) Mr. R. A. Hadfield has recorded experiments proving the same thing, and Mr. T. W. Hogg at the Brussels meeting of the Iron and Steel Institute, 1894, gave full analysis of a large number of castings cast in sand and in chills. Founders and experimenters in this country have from time to time given results of adding aluminum to cast iron and without exception sustained the results of previous experiments. But while these facts are fully proved, yet the practical way to regulate the color, softness and strength of a casting is to vary the silicon.

When a great variety of sizes of castings are to be made in one day it would be well to vary the silicon in different cupola charges, so that the iron poured into large castings would contain less silicon than that poured into small castings.

Another correspondent wanted to know what constituted the best iron for stove plate castings and Mr. Keep gives this reply:

This depends upon the location of the foundry. The mixture must be made of irons which can be purchased in that locality at a reasonable price.

Castings which contain from 2.75 to 3.50 per cent of silicon are less liable to crack by the sudden changes of temperature to which they are subjected. They are also soft. The only question is how to get silicon into the casting. The pig iron must contain the right amount or else silvery iron must be used.

In Troy and Albany before the influence of silicon was understood it was thought that the best pig iron for stove plate was made from soft hematite ores which were not too rich in iron, and it will be found that the pig irons most used at present are those made from red hematite ore, though there are some brown hematites that will make a non-chilling iron. Most of the southern foundry iron is made from red hematite.

The same letter asks for the chemical analysis of good stove plate.

It will be carbon about 3.25, about 0.30 of which will be combined; silicon from 2.75 to 3.25, phosphorus about 1 per cent, sulphur about .06, though 0.10 will do no harm. The constant remelting of sprues will often raise sulphur to this last per cent. Manganese will be about 0.5. This iron would be fluid and soft and will make smooth castings.

Referring to an inquiry as to what constituted the best material for fluxing purposes Mr. Keep says:

Limestone seems fully as good as fluor spar and is much cheaper. I think when thin castings with large surfaces are to be made the surface will be better with limestone. It is the lime in the stone that is desirable. The silica and magnesia are undesirable. The stone that contains most lime is the out-crop, which has long been exposed to the weather. Stone taken out of the same quarry at considerable depth will often contain as much magnesia as lime. The chips from a stoneyard are of this nature and are not the best for fluxing. Oyster shells or marble chips

would be good. The only good a flux can do is to make a fluid slag in the cupola through which the drops of melted iron can sink and be protected from the blast. Where the whole iron melted does not fill the cupola more than 10 or 12 feet above the bed there is no need of using flux unless a little is thrown in with the last charge to make a cleaner drop and to make it easier to break up the dump.

If a large quantity of iron is melted in one cupola the slag must be drawn off so as not to clog the cupola. Flux is used to make it fluid enough to come out of the slag hole. By making the hole of the right size the slag will run continuously without much air escaping. The least possible daubing should be used in repairing the cupola, just enough to hold the necessary pieces of firebrick in place. The daubing is composed of fire clay and sharp sand, both of which when combined with lime form a fluid slag. The more daubing the more slag.

In this issue is also shown a portable rammer in use at the foundry of the Wm. Cramp & Sons Ship & Engine Building Co., or as it is popularly known, the I. P. Morris Foundry.

This rammer is the invention of Mr. Joseph Cramp, to whom patents have been granted. So far the principal use to which it has been put has been in the ramming up of pits for loam molds, where it readily performs the work of a dozen laborers, besides doing the work in a better manner, ramming the sand harder and more evenly. The rammer, which requires but one man to operate it, is swung on a light crane, supported on the columns or wall of the foundry. This crane as constructed can readily be moved to any part of the foundry, where it is desired to utilize the rammer, or the latter may be attached to a common crane. Besides its utility in ramming up the pits around the loam molds, it has become almost indispensable in ramming up large green or dry sand molds or work bedded in the floor, where a large amount of muscle is usually required.

W. H. Kremer writes an article on "Malleable Iron," in which he speaks thus of the earlier manufacture of this metal:

It has not been many years ago when, with the exception of chains and a few minor light castings, this metal was not used by agricultural implement makers who are now employing this material exclusively for castings on many of their tools. Its uses at that time were limited to cheap harness and buggy work, keys, small household tools and light hardware.

A well-grounded prejudice existed against castings in malleable iron of such dimensions as are now successfully made every day, and with the exception perhaps of a half dozen concerns, it was almost impossible to secure a reliable casting of twenty pounds in weight.

Cupolas were largely used for smelting the iron. The latter in nearly all cases was iron from the "Salisbury" district. Later plants were erected in the west, also employing cupolas, which used Lake Superior, "Salisbury" and Baltimore irons.

The knowledge in the making of this iron was not as general as it should have been, and many factories depended upon Salisbury pig as their only hope. When satisfactory results were not obtained from their mixtures more Salisbury was used, and it generally accomplished the purpose. A great and deserved faith was put in this iron as it was about the only iron on the market at the time which could be used exclusively in the mixture.

The "Natural Draft Air Furnace" could use up only a portion of sprues made, hence the extra sprues were melted in a cupola and cast into the lighter work. Although the sprues bring a refined iron when put into the cupola, the castings after annealing, were much inferior in malleability to those cast from the air furnace owing to the absorption of detrimental elements during its fusion.

Sometimes when the furnace would be working poorly and "rush" orders be piled up on file, it would be found "expedient" to cast other than "light work" from the cupola. This practice did a great deal to form the prejudice mentioned before, for in nearly every instance some "kick" would be made about some casting or other breaking, while the balance would probably escape the strain given the broken one and pass on to the final consumer, from whom the malleable iron men never heard.

The introduction of the forced draft air furnace enabled the melting of all the sprues made in the shop. Foundries supplied with this furnace did not have to resort to a cupola, with the exception of those plants having very light work.

With the use of this furnace a more reliable and uniform iron has been made, not only to the satisfaction of producers, but to consumers in general. It has, and is being adapted to almost every conceivable purpose where a strong and malleable metal is desired.

#### MACHINERY.

In the February number of this journal Herbert E. Field has an article on "Test Bars and Their Relation to the Strength of Castings," in which he says:

Periodically such discussion of test bars as Messrs. Keep, West and Dr. Moldenke are now indulging in, are brought to the attention of readers of industrial and scientific journals.

It has always appeared to me that this controversy over the merits and demerits of the  $\frac{1}{2}$ -inch square bar and the 1-inch square or round bar, has been an instance of the one stopping his ears while the other talks, and vice versa. I think that a careful study of the situation will reveal that, while both may be correct to a certain extent in the limited square to which they confine their experiments and arguments, yet, when we consider the test bar in the broader sense as a universal standard for determining the strength of iron in castings, the methods advocated by them fall far short of the excellence claimed.

#### Test Bars.

It is not my intention to discuss, at any length, the relative value of the inch or  $\frac{1}{2}$ -inch bar; but I wish to show, if possible, where both fail to accomplish the purpose for which they are, or at least should be, used. However, before commencing this, the most important part of this article, let me write a few words to those who insist upon using this method of testing their iron.

Of the large number who break the transverse bar from each cast, I should like to know how many carefully caliper the bar;

how many note the difference in size between the ends of the bar adjoining and opposite the gate, and how many realize what a proportionately great difference in the strength of the bar a very slight difference in the height or in the diameter makes. I think I may safely say that not one in ten takes the above precautions. No molder, however careful, can cast two bars from the same pattern exactly alike. Whether the bars be cast on end or flat, there is bound to be a difference in the size of the bar at the opposite ends, unless an allowance for this variation is made in the construction of the pattern.

Whenever a new pattern is needed, it is probably measured carefully by the foreman or whoever makes the test, and perhaps for the first day or two the bars may be measured, but after that they are broken either as  $\frac{1}{2}$ -inch or 1-inch bars and recorded as such, while in reality there may be a difference in size sufficient to cause the tester to wonder what can have happened to his mixture. So the poor melter or the much abused pig iron agent may have to stand the blame, which is solely due to the fact that his bar is a thirty-second small and that he hasn't noticed the deficiency. If you find that you are using the same mixture two days and get different results, measure your test bars at the point of rupture and see if they agree.

The fact that the bars are somewhat larger at one end than the other, makes the accurate measuring of a rough bar difficult. For although you may get the approximate size at the center of the bar where the knife edge is to bear, in many cases the bar does not break at that point. A measurement taken at the break afterwards is of no value except for comparison, since the bar generally decreases in size under strain. Another point which is quite noticeable is the fact that there is a difference in strength between the two ends of the bar, depending upon how the bar is cast. This can be best proven by turning small tensile specimens out of opposite ends, or where this is not possible, by cutting the bar in the center and by decreasing the distances between the supports in your testing machine and by breaking each half separately.

A few foundries, noticing the above faults, cast their test bars an eighth to a quarter of an inch large and have them machined in the center (only) down to the required size. This is a very good plan, and not only does away with the liability of the bars varying in size, but insures their breaking in the center, and thus makes all the tests uniform.

The above faults to be found in the transverse test, together with the recognized fact that all rectangular bars develop marked weakness lines in cooling, leads up to the second fact that I wish to bring out—that is, the great advantage of the tensile over the transverse test. The tensile strength of cast iron is very much in excess of its transverse strength. Hence, even if the rough bar is tested, the proportionate variation in strength, due to a small difference in diameter, is much smaller in the case of the tensile test. In nearly every series of experiments carried on in this line, it has been shown that as the transverse strength increases, the hardness increases. This is certainly true up to a point where cast iron is much too hard for ordinary uses. Tensile tests, on the other hand, serve as a very accurate guide to the quality of iron. The old theory that high tensile strength irons are always hard irons has long been disproved. Hence, if one can improve the tensile strength of his iron, he is almost sure to be improving its physical qualities. The strongest iron which I have ever tested gave a tensile strength of 44,000 pounds per square inch, and was one of the best irons to machine. It is for this reason that I urge upon foundrymen the advisability of the use of the tensile test when it is possible. The first cost may be somewhat greater, but the results are enough superior to warrant the outlay.

#### TEST BARS VS. CASTINGS.

The tendency of to-day is to aim first to get iron test bars strong, regardless of the other qualities of iron which go to make up the perfect casting. When competition is as strong as it is to-day, the saving in machine work on the casting has often much to do with the ability to do work cheaply. Therefore, in mixing iron for machine work this should be kept constantly in mind.

The number of castings which require a high strength is comparatively small, so that softness of iron should in many cases be considered rather than a boasted strength, which in the specific instance may be of no real value to the casting.

The fact that a  $\frac{1}{2}$ -inch or inch square bar has been cast out of the same ladle as a certain casting, and that the bar shows a high transverse test, is generally taken to mean that the casting, regardless of its size and strength, has the same strength. It may have, but the probability is that it has not. The iron has been cast into molds of entirely different shape and thickness. The quality of the sand and the moisture it contains are sure to vary. Thus the test and the casting will cool under entirely different conditions. If the casting be very much thicker than the test bar, as is often the case, the test bar will set cool, and perhaps be dumped out of the flask before the graphite has ceased to separate in the iron of the casting. On the other hand, if the casting be stove plate or other thin work, the opposite may be true.

Will there be any similarity between irons cast under such different conditions? Let us suppose that we are running a stove plate foundry and on a certain day the transverse strength of the  $\frac{1}{2}$ -inch square test bar, in the course of treatment by Mr. Keep's mechanical analysis, falls a few hundred pounds below the standard that we have fixed for our work. Something must be done. So we judge either from the above named analysis, or for some other reason, that our iron is running a little too soft. We proceed to harden it for the next heat. On the following day we find that we have regained our old standard, and congratulate ourselves accordingly. But for what? For the fact that we have added 200 pounds strength to a  $\frac{1}{2}$ -inch square bar, while ten chances to one we have weakened every casting made that day. If you do not believe this statement, try for yourself. Take one of your  $\frac{1}{2}$ -inch test bars and have it turned to a tensile test. Then take a piece of your thin casting and treat it likewise. If your machine will not break it, send it where it can be broken. If you are convinced of this fact, it may save you dollars that you are now expending in useless tests.

Let us make one more supposition. Suppose you are using the 1-inch test bar and find that, for some unexplained reason, it falls in strength. You are making a heavier grade of casting from  $1\frac{1}{2}$  to 2 or 3 inches in thickness.

You find, perhaps, that your scrap is running a little harder than usual, and so by use, say, of a higher silicon iron you bring your 1-inch test back to its required strength. But how about the casting? Instead of softening, it, being of large dimensions, probably needed the opposite treatment, and yet, in order to bring an unused test bar up to a certain strength, you have weakened the more important pieces. The question is, Are you working to improve your castings, or are you working to gain some standard strength in a test piece which may or may not represent in any degree the strength of any casting in the heat? The question here arises, Is there no way to determine the true strength of the iron in our casting? There are two methods.

The first, and it is preferable when possible, is to take a test out of some representative casting which has been rejected on account of a defect. Most foundries have such castings occasionally. In this way, and in this way only, can the testing be said to represent truly the strength of the iron in the casting. One test a week made in this way is worth more than the thirty or forty transverse bars that many foundries break in an equal time. You know what your iron is in your casting. They know what it is in their test bars, which is a very different thing.

The second method is to cast a test in the casting of such shape and in such a position as will best give the true strength of the casting. This is the only method that can be used when the strength of a specific casting is desired. The test bar, while not exactly the casting itself, is cast under precisely the same conditions, and gives a fairly accurate test of the casting. The test piece should, if possible, be made to correspond to that part of the casting which, on account of its size or position, is most liable to break. In this way, by ascertaining the strength of the weakest part, we have the true strength of the casting.

It will soon be recognized, I feel certain, that the present tendency to work for test bars, and thus neglect the strength of castings, is an erroneous one. The plea of Dr. Moldenke for a universal uniform test bar appears to be not only an impossibility, but also an absurd proposition. The one fact that it is possible to pour from one ladle of good iron a series of tests which shall vary from 15,000 to 27,000 pounds tensile strength, should show this. Many will probably at first doubt this statement, but they can prove it for themselves by simply making the pieces cast of sufficient variation in size.

A simpler way, perhaps, is to take three or four parts of different thickness out of some rejected casting. Let these pieces vary as much as possible in thickness.

If a set of standard test bars were agreed upon in order to represent to any degree of correctness the strength of cast iron, the number of those standards must be legion. There would have to be as great a number of bars as there are thicknesses of casting, and they would have to be cast under as many and as varying conditions.

Many of the readers of this paper have often wondered, as I have, at the extraordinary high tests obtained by the so-called semi-steel people. You may believe what you wish, and they may assert what they please, but, to my mind, only the smallest of the castings—say, those not exceeding 1 inch in thickness—would ever reach anywhere near the strength that their lists record.

Every test which I have seen recorded by them has been turned from a bar of 1 inch or less in diameter. A brief personal experience will show how I was led to believe this, and it perhaps may be of value to others. A short time ago one of the officers of the corporation by which I am employed pointed out to me four tests recorded in the report of "Tests of Metals," issued by the Ordnance Department of the United States Government. These tests were sent to Watertown Arsenal, and were broken in the government Emery testing machine.

In a joking way he asked me why I didn't reach the 42,000 to 49,000-pound tests recorded there. I called his attention to the fact that they were taken from small bars, two being but 1 inch square, while two were only  $\frac{1}{2}$  inch square. I then went out into our yard, and picking up an ordinary drop gate of about  $1\frac{1}{4}$  diameter, had it turned up and tested. It gave a tensile strength of 40,000 pounds per square inch, while the test which represented the true strength of the casting had given but 30,000. Another incident which happened last week is only another of the many which go to confirm the fact, that you can get almost any strength out of iron if you only have it cast in the correct form and size.

I picked a piece of water pipe out of the scrap heap and had it turned up till it was about a sixteenth of an inch thick, and when broken it gave a calculated strength of 27,000 pounds per square inch, or only 700 pounds below the government requirement for gun iron. This was made from a mixture of machinery scrap and a No. 2 Southern coke iron. These go still further to show how little relation there is between the strength of test bars and the strength of the iron in the castings.

Of course, in special contract work, where certain specifications are furnished as to strength, etc., it is necessary to work to those tests which are specified. It is, however, frequently the case that inspectors reject castings where the test plugs fail, when a test taken from a casting would have stood the test, and many, I fear, are accepted where the test plug is up to the strength, when the iron in the casting would not stand an equal test.

If there is an object in view, it is well enough to work to your test; but when a founder is working simply to improve his own product, he should by all means endeavor to improve his castings, and not the strength of a  $\frac{1}{2}$ -inch or 1-inch test bar.

The discussion as to whether a  $\frac{1}{2}$ -inch bar or a 1-inch bar test "indicates degrees in the strength of the iron to agree with the chemical analysis," appears to me to be a mere waste of time and words. Every iron having a certain chemical analysis has, theoretically, a certain sized test piece that will give it a maximum

strength. Without a doubt, the  $\frac{1}{2}$ -inch test bar better coincides with the chemical tests of stove plate than would a 1-inch bar. A test taken from the different thicknesses of plate would, however, coincide much better.

I hope that in the few notes that are written above, I may have led some at least to think a little more deeply upon this subject of stronger castings versus stronger test bars.